Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Establishment of an Improved Model for Predicting the Broadcast Television Field Strength Received at Individual Locations	)))	ET Docket No. 00-11

Comments of Fox Television Stations, Inc. and Fox Broadcasting Company

Fox Television Stations, Inc. ("FTS") and Fox Broadcasting Company ("FBC," and collectively with FTS, "Fox") respectfully submit these comments in response to the Commission's Notice of Proposed Rulemaking in the above-captioned proceeding ("*NPRM*") on the establishment of a point-to-point model for predicting the broadcast television signal strength that individual locations can receive with the use of a conventional, stationary, outdoor rooftop receiving antenna.

Introduction

The Commission's goal in this proceeding, as set forth in the Satellite Home Viewer Improvement Act of 1999 ("SHVIA"),[1] is to develop a reliable model

[1] SHVIA, Title I of the Intellectual Property and Communications Omnibus (continued...)

for determining presumptively whether particular households are eligible to receive network programming from distant stations via satellite.[2] The SHVIA directs the Commission to take into account terrain, building structures, and other land cover variations. To that end, the Commission is proposing to add clutter loss parameters to the Individual Location Longley-Rice ("ILLR") model recommended in the *Report and Order* in CS Docket 98-201 ("*SHVA Report and Order*").[3] Specifically,

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1 (...continued)
Reform Act of 1999, PL 106-113, 113 Stat. 1501 (1999).

2 Section 339(c)(3) provides:

> Within 180 days after the date of the enactment of the Satellite Home Viewer Improvement Act of 1999, the Commission shall take all actions necessary, including any reconsideration, to develop and prescribe by rule a point-to-point predictive model for reliably and presumptively determining the ability of individual locations to receive signals in accordance with the signal intensity standard in effect under section 119(d)(10)(A) of title 17, United States Code. In prescribing such model, the Commission shall rely on the Individual Location Longley-Rice model set forth by the Federal Communications Commission in Docket No. 98-201 and ensure that such model takes into account terrain, building structures, and other land cover variations. The Commission shall establish procedures for the continued refinement in the application of the model by the use of additional data as it becomes available.

3 *Satellite Delivery of Network Signals to Unserved Households for Purposes of the Satellite Home Viewer Act; Part 73 Definition and Measurement of Signals of Grade B Intensity*, adopted February 1, 1999, 14 FCC Rcd 2654 (1999).

the proposed model would assign the Rubinstein clutter loss values[4] to categories of reception environments. These values would, in turn, be added to the radio propagation loss predicted by Longley-Rice 1.2.2.

As we shall demonstrate, the Rubinstein data is not suitable for predicting the signal strength of broadcast television signals at individual locations. We also identify the pitfalls of grouping diverse reception environments into the broad categories proposed and the fallacy of presuming lack of service when error codes are generated. In sum, no adequate methodology yet exists for taking buildings and land cover variations into account. In light of the Congressional intent that the Commission develop a "reliable" predictive model, Fox submits that the Commission should refrain from taking any action at this time to take buildings and land cover into account. Instead, the Commission should, as contemplated by Congress, readdress this issue when it can engage in "continued refinement in the application of the model by the use of additional data as it becomes available."[5]

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4 Thomas N. Rubinstein, "Clutter Losses and Environmental Noise Characteristics Associated with Various LULC Categories," *IEEE Transactions on Broadcasting*, Vol. 44, No. 3, September 1998.

5 Section 339(c)(3).

Clutter Loss Values

The Rubinstein data is not appropriate for predicting the television broadcast signal strength that a conventional rooftop antenna at a particular location could receive. The tests used to generate the Rubenstein data involved a receiving antenna on the roof of a moving vehicle, which we estimate to have been about six feet above ground. ILLR assumes a receiving rooftop antenna 20 or 30 feet above ground,[6] i.e., above adjacent buildings of similar height and low ground cover such as bushes and short trees. Rubinstein's test results show signal degradation from obstacles that will not affect the radio path to an outdoor rooftop antenna placed 20 or 30 feet above ground. Also, because measurements were taken while the vehicle was moving,[7] the effects of dynamic multipath would have affected the received power level.

Rubinstein's clutter loss values were derived by comparing the measured signal strength with the signal strength predicted by a modified version of Okumura's algorithm.[8] Accordingly, the Rubinstein clutter loss values are tainted by the imperfections and inapplicability of the Okumura model, which is a cellular telephone propagation model based on empirical curve-fitting and which supposes

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6 *See NPRM* at A-1.

7 *See* Rubinstein, *supra* note 4, at 286.

8 *Id.* at 288.

that the transmitting antenna is only about 100 feet above the ground, not the typical 1000 feet of a television station's transmitting antenna.

Rubinstein's measurements were made using vertical polarization, whereas television principally uses horizontal polarization. ITU documents note that foliage losses are typically less for horizontal than vertical polarization in the frequency bands used for television.[9]

The *NPRM* points out another problem with the Rubinstein data: the data does not cover low-band VHF television. To remedy this problem, the Commission proposes to extrapolate clutter loss values for low-band VHF television using Okumura frequency trends.[10] The *NPRM* cites no reasonable engineering basis for deriving values in this manner, and we are aware of none.

In short, Rubinstein's test methodology did not replicate the receiving location of a conventional, stationary, outdoor rooftop receiving antenna and did not use the planning factors typical of a television broadcasting station, which place the receiving and transmitting antennas well above much of the ground clutter. The Rubinstein clutter loss values, therefore, are exaggerated and would lead to under-predicting service.

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9 *See* "Attenuation in Vegetation," Rec. ITU-R PN.833-1.

10 *NPRM* at ¶12.

Reception Environment Categories

In an effort to "simplify" the ILLR database, the *NPRM* proposes to combine the already broad categories of reception environments listed in the Land Use and Land Cover ("LULC") database of the United States Geological Survey.[11] A single clutter loss value would be assigned to each of the 10 generalized categories proposed. One such category is "forest land," which would include deciduous forest land, evergreen forest land, mixed forest land and forested wetland.

While combining these types of clutter may simplify the database for ILLR purposes, it does not render the methodology more accurate or reliable, which is the goal of this proceeding. The losses of various types of ground clutter vary wildly. For example, the losses from deciduous trees will be higher in the summer when they are fully leafed than other times of the year. Also, trees grow; a tree that is not an obstruction today may be an obstruction five years from now. The losses from different types of houses change dramatically depending on the radio opacity of the materials used in constructing the house. Further, the LULC database does not provide any height information, and, accordingly, the broad categories of reception environments proposed in the *NPRM* do not distinguish among obstructions of

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11 *NPRM* at ¶10.

different heights. Without height information, no reasonable calculation of loss is possible.

As Rubinstein points out, the LULC "categories are not ideal for application to radiowave propagation,"[12] and the *NPRM*'s proposed over-generalization of types of ground clutter will not produce reliable predictions of service or lack of service.

Error Codes and Presumption of Lack of Service

The *NPRM* proposes to presume a lack of service whenever a KWX numeric error marker greater than 1 is generated with a prediction. This proposal would depart from ILLR as endorsed in the *SHVA Report and Order*, would lead to biased results, and would relieve satellite carriers of the statutory burden of proving that a household lacks service.

In the *SHVA Report and Order*, the Commission rejected arguments that households should be deemed unserved when Longley-Rice presented an error code. The Commission stated: "If we change the model's assumption of service so that it assumes no service, we risk shifting the satellite carriers' burden of proving (through actual testing) that a household is 'unserved' in such a way that appears to

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12 Rubinstein, *supra* note 4, at 286.

contravene the statute."[13] Instead, the Commission decided that if a prediction was coupled with an error code, a party could either ignore the error code and accept the prediction—whether it was a prediction of service or lack of service—or could conduct an actual measurement at the location in question.[14] The Commission has failed to explain adequately in the *NPRM* why it is now reasonable to determine presumptively that a location is unserved because of a flaw in the predictive methodology.

An Improved Predictive Model

The Longley-Rice model is more than thirty years old and hardly represents the "state of the art" in accuracy. The Commission's statutory mandate to develop and refine a point-to-point predictive model should not be read narrowly to limit the Commission to some variation of Longley-Rice. Fox recommends the adoption of a modern, fully vetted model. We strongly recommend the use of Illinois Institute of Technology Research Institute's ("IITRI") version of the Terrain Integrated Rough Earth Model ("TIREM"), Version 3.09 or later, which is available on commercially reasonable terms from IITRI. TIREM does not have the "KWX"

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13 *SHVA Report and Order* at ¶85 n.219.

14 *Id.* at ¶85.

problem that renders many of the Longley-Rice model's predictions suspect. TIREM is used by the Department of Defense for mission critical applications by the military. We are attaching a report on the accuracy of TIREM.

Regardless of which methodology the Commission finally adopts, the accuracy of prediction would be materially improved by using real radio refractive data instead of using one value (i.e., the traditional 301 (Ns) or 1.333 (k)) to represent the entire United States. The use of real radio refractive data would enhance accuracy especially in the fringe areas. In the past, Fox has obtained machine-readable Ns/K data from IITRI; we also believe this data is available from other government sources.

Conclusion

The Congressional intent, as expressed in the SHVIA, is for the Commission to develop a more accurate and reliable predictive model and to refine that model over time. The current proposal—to assign rough values, which were derived from inapplicable testing methodologies, to broad categories of receiving environments, which are not suitable for radiowave propagation—will make ILLR even less reliable, which is contrary to the statute's direction. Congress, by requiring "continued refinement in the application of the model by the use of additional data as it becomes available,"[15] recognized that in this initial action, not all necessary information may be available. Because an appropriate application for considering the effect of land cover on signal intensity does not yet exist, Fox urges the Commission to wait until an accurate method becomes available before incorporating such parameters into the predictive methodology.

Respectfully submitted,

FOX TELEVISION STATIONS, INC.
FOX BROADCASTING COMPANY

By: ______________________
John C. Quale
Linda G. Morrison
Linda G. Coffin

Skadden, Arps, Slate, Meagher & Flom LLP
1440 New York Avenue, N.W.
Washington, D.C. 20005
(202) 371-7200

Their Attorneys

R. Evans Wetmore, P.E.,
Vice President,
Advanced Engineering,
News Technology Group
News Corporation

Dated: February 22, 2000

[15] Section 339(c)(3).

TERRAIN INTEGRATED ROUGH EARTH MODEL (TIREM) VERIFICATION AND VALIDATION (V&V)

Technical Report

Prepared by:

IIT RESEARCH INSTITUTE
CENTER FOR ELECTROMAGNETIC SCIENCE (CEMS)
4409 FORBES BOULEVARD
LANHAM, MD 20706

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SECTION 1
TIREM MODEL DESCRIPTION

INTRODUCTION

TIREM is a radio-frequency propagation prediction model that is valid for frequencies between 1 and 20,000 MHz. TIREM requires information about the terrain profile, characterized as terrain elevation points along the great-circle path between the transmitter and receiver. TIREM uses the terrain elevation data to determine the predominant mode of propagation and to compute the propagation loss. To construct the profile, TIREM uses digitized terrain-elevation data (DTED) supplied by the Defense Mapping Agency (DMA).

V&V DOCUMENTATION

The V&V documentation for TIREM provides a description of the model, and the status of the current model versions.

TIREM Description

TIREM consists of a set of modules whose primary outputs are the calculated basic median propagation loss and the mode of propagation. TIREM examines the terrain profile between two isotropic antennas to determine the predominant mode of propagation. If the path is line-of-sight (LOS), the loss above the free-space loss is estimated as the smaller of the reflection-region loss due to terrain intrusion into the first Fresnel zone or the spherical-earth loss for an assumed all-land path. If the profile contains sea water, two loss calculations are performed. First, the loss is computed for an all-land path and then for an all-sea path. The loss above free-space is computed as a combination of the all-land and all-sea loss, weighted by the roportion of land and sea segments along the entire path. The path loss is the sum of the free-space loss, the loss above free-space, and the loss due to atmospheric absorption for frequencies above 10 GHz.

If the path is beyond line-of-sight (BLOS), an extension of the Epstein-Peterson[1-1] method is used to calculate knife-edge diffraction losses. If the number of knife edges along the path exceeds three and the average knife-edge diffraction loss is greater than seven decibels, the terrain is regarded as "rough." In this case, the total diffraction loss above free-space is computed as the sum of the individual knife-edge losses and the reflection-region losses between the transmitter and its horizon and the receiver and its horizon. If sea water is present in the terrain profile and diffraction occurs on sea water, spherical-earth losses for segments of water around which diffraction occurs are included. If the average knife-edge loss is less than seven decibels, the terrain is considered "smooth" and the spherical earth loss is approximated using a spherical-earth model with ground constants representative of land. If sea water is present along the terrain profile, the spherical-earth model is used again with ground constants corresponding to sea-water to calculate the spherical-earth loss.

The total loss above free-space is a combination of the land and sea losses, weighted by the proportion of land and sea along the terrain profile. The diffraction loss is set to the minimum of the spherical-earth loss and the rough-earth loss. The total diffraction loss is computed as the sum of the free-space loss, the total diffraction loss above free-space, and when the frequency exceeds 10 GHz, the loss due to atmospheric absorption. Next, the total tropospheric loss is calculated and if the frequency exceeds 10 GHz, the loss due to atmospheric absorption is added. The total path loss is then set to the smaller of the total diffraction loss and the total tropospheric loss.

Development History

The development of rough-earth models began with the formulation of techniques for extracting the necessary parameters for evaluation of the path from great-circle terrain profiles, selection of the appropriate mode of propagation, and calculation of the loss. Many of the concepts and algorithms employed in TIREM were based on work done at the Central Radio Propagation Laboratory (CRPL) of the National Bureau of Standards (NBS).[1-2] The CRPL has since become the Institute for Telecommunication Sciences (ITS) of the National Telecommunications and Information Administration (NTIA).

Early TIREM versions included LOS modes (including free space) and three BLOS modes. There was also a spherical-earth mode which served as a recovery model when rough-earth engineering models were not applicable. In 1983, TIREM was reconfigured to include three LOS modes, five diffraction modes, and five combination modes involving tropospheric scatter or diffraction. Later, in response to the user community's observations that several prediction modes for the BLOS were inaccurate, these calculations were improved by combining diffraction calculations into a single unified mode based on diffraction over multiple knife edges. Also, in the transition region between propagation by diffraction and propagation by troposcatter, a new, single mode replaced several transition modes. This modified version of TIREM became TIREM Version 1.0

In Version 2.0, a smooth spherical-earth propagation mode was added for path segments over smooth-water surfaces. Losses for water segments are combined with multiple knife-edge diffraction losses for land segments, weighting each by the proportionate distances of water and land in the entire path.

TIREM 2.0 was completely rewritten as a callable subroutine to facilitate its integration into analysis models and named TIREM Version 3.0. Also, several algorithms were revised to simplify the calculations and reduce the run-time without affecting the model's accuracy. Recent changes to TIREM have focused on simplifying the calculations and reducing computation time. These changes are summarized in Table 2-1.

Table 2-1. Summary of Recent Changes to TIREM

TIREM Version No.	Description
3.00	Original model rewritten as a callable subroutine
3.01	Corrected frequency gain function calculation in Troposcatter algorithm (TROSC).
3.02	Hertzian dipole antenna equations were replaced with isotropic antenna equations (SEARTH).
3.03	Incorporated the COST 210 troposcatter algorithm (TROPSC).
3.04	Returned to original troposcatter algorithm due to problems with COST 210 method (TROPSC). Additional changes in Version x.03 not associated with troposcatter algorithm were retained.
3.05	Corrected problem in diffraction calculation when water is present along the path (DIF).
3.06	New methods were added to calculate the distance to the last interference maximum and the last interference minimum. Subroutine SEARTH was modularized. Linear interpolation was added between reflection loss and spherical earth loss for land paths in the 16 - 20 MHz range (TIRLOS).
3.07	RFC2AK was modified for antennas greater than 475 km. This has no effect on TIREM/SEM since antennas of this height are out-of-range for these models. Precision problems across platforms were corrected.
3.07A	For antennas very close to the ground, a divide by zero error occurred during calculation of the distance to the last interference maximum. For this case, the distance was set to zero (SEARTH).
3.08	Corrected program to give consistent results when profile extension flag is used.
3.09	Corrected inconsistency reported by IEWD in TIREM. Subroutine RF2CK was returned to its original form.

Current Model Version Status

The current version of TIREM is Version 3.09.

SUMMARY OF ASSUMPTIONS AND LIMITATIONS

TIREM does not account for the effects of man-made or natural obstructions (e.g., foliage) unless the terrain profile has been adjusted to account for these features. In addition, the effects of reflections from obstructions or terrain not located along the great-circle path between the antennas are not considered.

For frequencies above 10 GHz, the atmospheric absorption due to molecular oxygen and water vapor is estimated using the 1962 US Standard atmosphere[1-3] and adjusted for the user-specified surface humidity.

None of the following factors that may affect path loss in practical situations are considered by TIREM:

- Ionospheric effects
- Ducting phenomena
- Long-term path loss variability (although these effects may be incorporated within the driver program)
- Multipath effects
- Absorption due to rain, foliage, or man-made obstructions.

DATA REQUIREMENTS

The input variables required by TIREM fall into five categories: (1) terrain profile, (2) transmitter-receiver antenna coupling, (3) ground constants, (4) atmospheric constants and (5) miscellaneous.

1. Terrain Profile

Three inputs describe the terrain profile:

- The first input is the number of profile points.
- The second input is the height above mean sea level of each profile point.
- The third input is the array of distances measured along the great-circle from the transmitter to each profile point.

2. Transmitter-Receiver Antenna Coupling

   Four inputs describe the transmitter-receiver antenna coupling:

   - The first input is the structural height of the transmitting antenna, in meters.
   - The second input is the structural height of the receiving antenna, in meters.
   - The third input is the polarization of the transmitting antenna.
   - The final input is the transmitter frequency.

3. Ground Constants

   Two inputs describe the ground constants:

   - The first input is the surface conductivity for the ground type over which the terrain profile lies.
   - The second input is the relative permittivity for the profile.

4. Atmospheric Conditions

   Two inputs describe the atmospheric conditions for the propagation path:

   - The first input is the surface humidity at the transmitter site.
   - The second input is the surface refractivity of the terrain profile.

5. Miscellaneous

   This input is used to reduce run-times when multiple runs are desired. This input eliminates unnecessary calculations when subsequent paths in the run file are an extension of the current path with the receiving antenna moved outward along the terrain profile.

The inputs required for TIREM and their corresponding ranges are summarized in Table 2-2.

Table 2-2. Summary of Inputs Required for TIREM

Description	Valid Range
Total number of terrain profile points	≥ 3
Terrain height above mean sea level	-450 to 9000 m
Array of great-circle distances from beginning of the profile to each profile point	≥ 0 m
Transmitter structural antenna height	0 - 30,000 m
Receiver structural antenna height	0 - 30,000 m
Transmitter antenna polarization: 'V' - vertical 'H' - horizontal	'V' or 'H'
Transmitter frequency	1 to 20,000 MHz
Surface conductivity	0.00001 - 100 S/m
Relative permittivity	1 - 100
Surface humidity at the transmitter	0 - 50 g/m^3
Surface refractivity	200 - 450 N-units
Profile indicator flag: .TRUE. - profile is an extension of preceding profile .FALSE. - new profile	.TRUE. or .FALSE.

SECTION 2
MODEL VERIFICATION AND VALIDATION

INTRODUCTION

Model validation may be done by several methods. The most effective method, however, is to compare the predicted outputs of the model with real-life measurement data. Another method is to compare the predicted output of the model under evaluation to the predicted output of another model known to produce accurate results. This model-to-model comparison is usually performed in instances when measured data is unavailable or when the validating model is known to predict results with great precision. Both methods were used in the validation of TIREM and SEM.

VERIFICATION AND VALIDATION

IITRI has performed extensive testing of TIREM against measured propagation loss data. Statistical data was compiled by comparing TIREM predictions to measured data that have been collected in various propagation measurement programs and stored in NTIA's Propagation Measurement File database.[2-1] Seven different propagation-measurement programs were used for the testing.

The data contained in the NTIA database was used to characterize the statistical accuracy of TIREM by comparing measured data with TIREM predictions for a large number of test scenarios. The frequency, path distance, and terrain type were varied among the test scenarios producing a large set of propagation profiles for which TIREM was intended to be used. The characteristics of the propagation-measurement programs are summarized in Table 4-1. The results of the TIREM validation are summarized in Table 4-2 for each of the propagation modes. The statistics shown in this Table are the mean and standard deviation of the loss difference L_{TIREM} - $L_{MEASUREMENTS}$. For all of the modes, the overall loss difference had a mean of -0.6, and a standard deviation of 10.5 dB.

Table 4-1. Summary of Terrain Characteristics Used in TIREM Validation

Location	Description
Worldwide[2-2]	No foliage effects are included since the data comprises measurements obtained by monitoring reliable communications links over long (yearly) periods. Path length: 10 - 800 km Frequency: 40 - 4000 MHz
Flagstaff, AZ[2-3]	Area is characterized by extremely rough terrain interspersed with flat areas. Foliage varies from dense forest to widely spaced trees to sparsely covered land in flat areas. Transmitter and receiver sites are relocated. Path length: 1 - 30 km Frequency: 2, 4, 8, 16, 32, 64, 128, 256, 400, 512, 800 MHz
Gunbarrel Hill, CO[2-4]	Receiver site is near the summit of a hill in the open plains of the Rocky Mountain foothills. Ten of the 55 transmitter sites associated with this receiver site are located in the mountains and only one of these results in a LOS path. Five transmitter sites are concealed by foliage. Path length: 1 - 120 km Frequency: 230, 400, 800, 1800, 4600, 9200 MHz
North Table Mountain, CO[2-5]	Receiver site is on a high mesa at the juncture between the mountains and plains and visible to most of its associated 59 transmitting sites. Path length: 1 - 120 km Frequency: 230, 400, 800,-1800, 4600, 9200 MHz
Colorado Plains[2-6]	Transmitter site is on a plain. Area has smoothly rolling hills east of transmitter. No vegetation or trees. Receiver sites are at fixed semicircular distances, approximately 120 sites. Path length: 5 - 80 km Frequency: 20, 50, 100 MHz
Colorado, mountains[2-7]	Same transmitter site used in Colorado plains measurement. Area has very rugged mountains west of transmitter. Woods and trees present, approximately 40 sites. Path length: 5 - 50 km Frequency: 20, 50, 100 MHz
Ohio[2-8]	Irregular and partly wooded terrain. Part of measurements taken with snow on ground. Receiver sites in approximate semicircles, with five peripheral transmitters. Approximately 250 sites. Path length: 5 - 50 km Frequency: 20, 50, 100 MHz

Table 4-2. TIREM Statistical Summary

Propagation Mode	Nominal Frequency (MHz)	Number of Measurements	Loss Difference (L_{TIREM} - L_{MEAS}) Mean (dB)	Standard Deviation (dB)
Spherical Earth	2, 4, 8, 16	102	-2.2	6.9
LOS	20, 32, 50, 64, 100, 400, 800, 1800, 4600, 9200	1,217	-2.8	8.9
Diffraction	20, 32, 50, 64, 100, 400, 800, 1800, 4600, 9200	2,798	0.2	11.4
Troposcatter	60 - 400	358	1.5	8.8
Total		4,475	-0.6	10.5

The most recent comparison of TIREM against measured data involved the measurements taken by Jørgen Anderson, in Denmark.[2-9] The measurements were used to validate the performance of TIREM for individual paths. The measurements include five terrain profiles in Northern Jutland near Aalborg, Denmark. The terrain profiles were located in rural areas with only small towns and forests. The important feature of these profiles was that they were along reasonably straight roads in mountainous terrain. Therefore, incremental measurements could be taken along the profile path with minimal lateral variations between the transmitter and receiver. The validation results could then be graphed as a function of path loss versus range.

The results of the comparison of TIREM to the measured data referenced by Anderson are shown in Figures 4-1 through 4-5. Measurements were taken at four frequencies at each site: 144 MHz, 435 MHz, 970 MHz, and 1900 MHz. The transmitter power was 10 watts with an antenna gain of 8 dBi. The receiving antenna was a quarter wave monopole with a gain of 5.2 dBi.

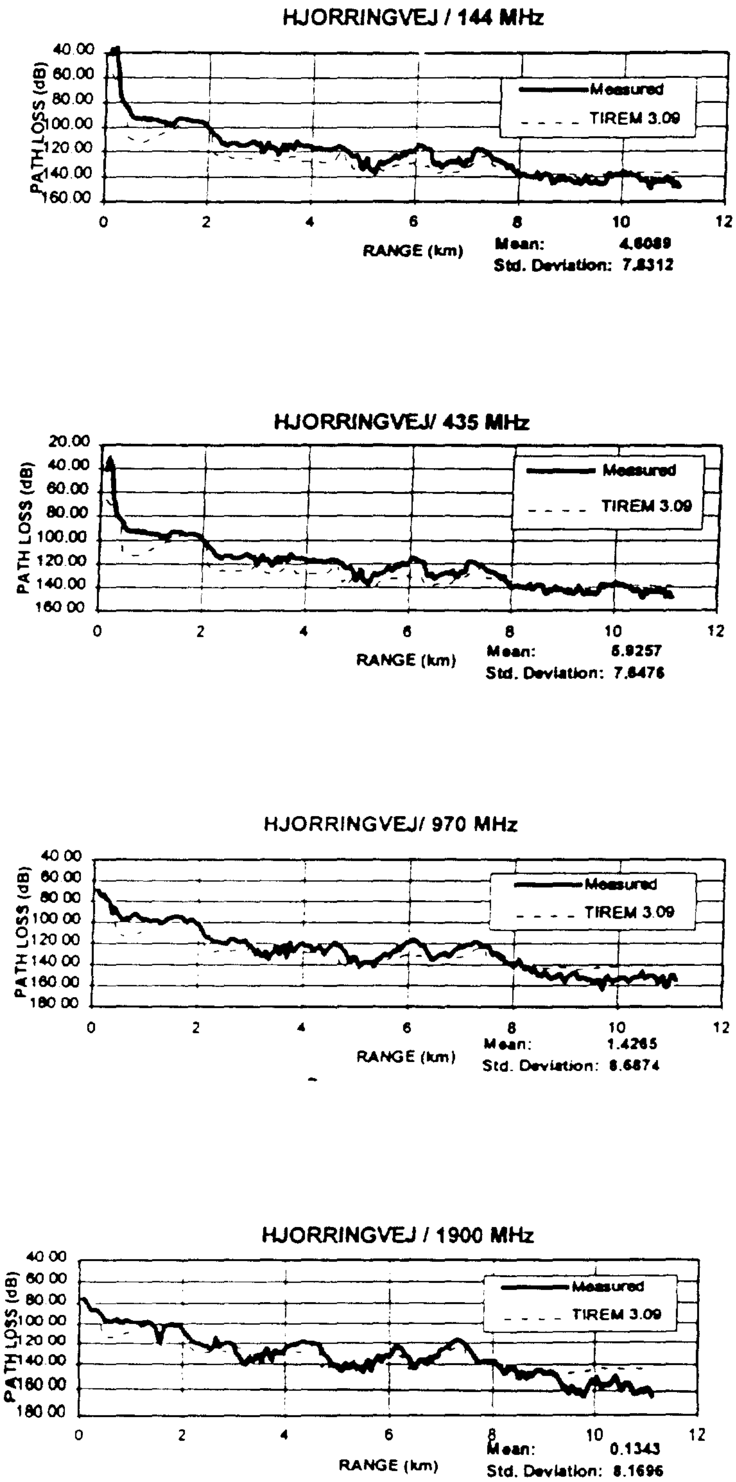


Figure 4-1. Comparison of TIREM 3.09 and measured data from Hjorringvej

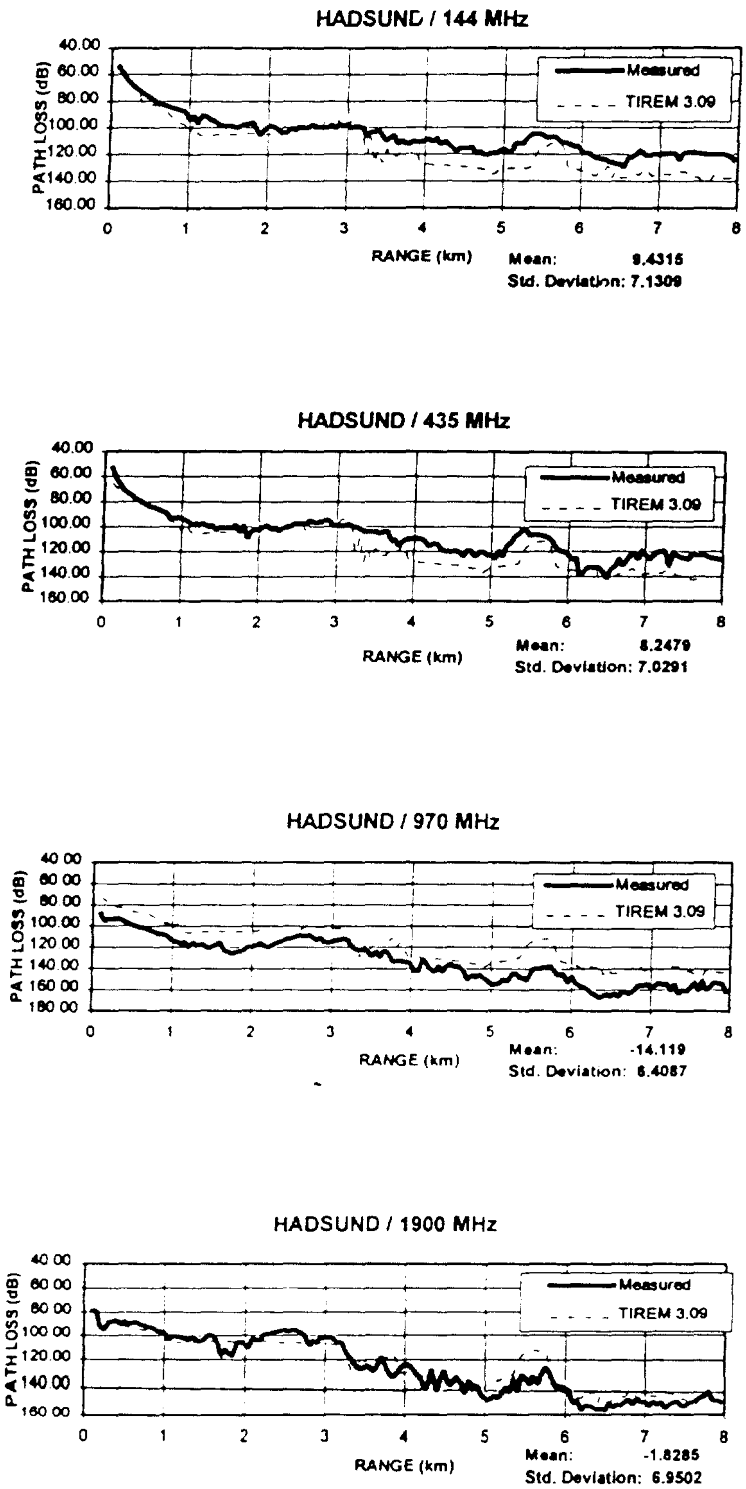
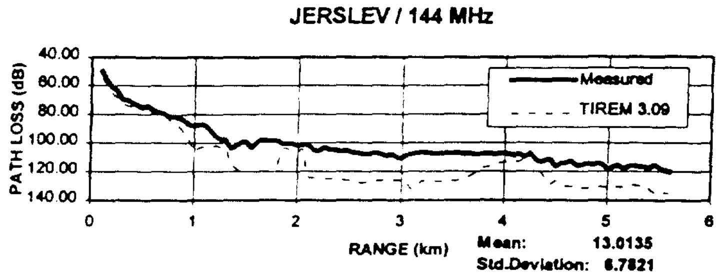
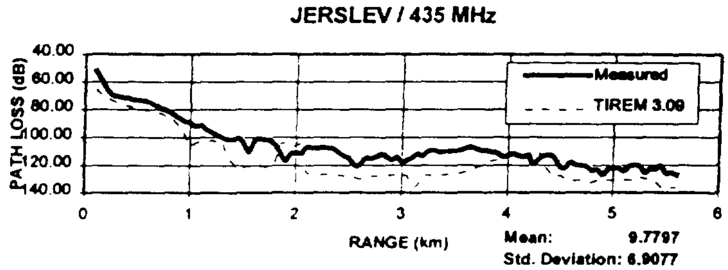
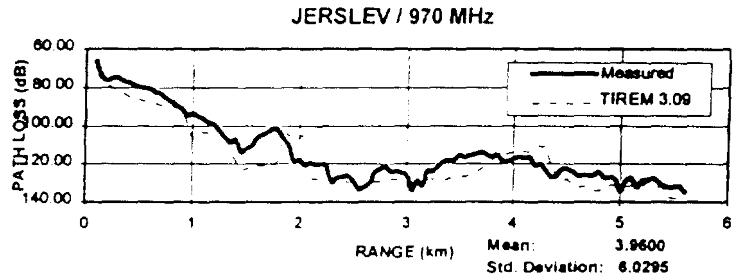


Figure 4-2. Comparison of TIREM 3.09 and measured data from Hadsund







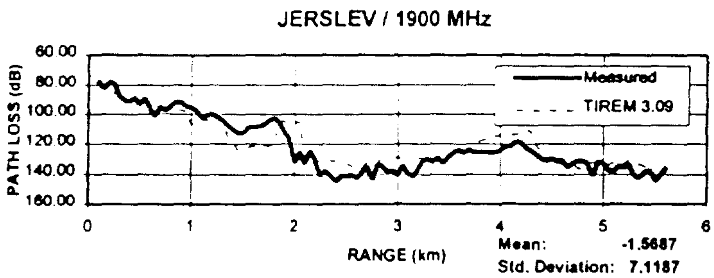


Figure 4-3. Comparison of TIREM 3.09 and measured data from Jerslev

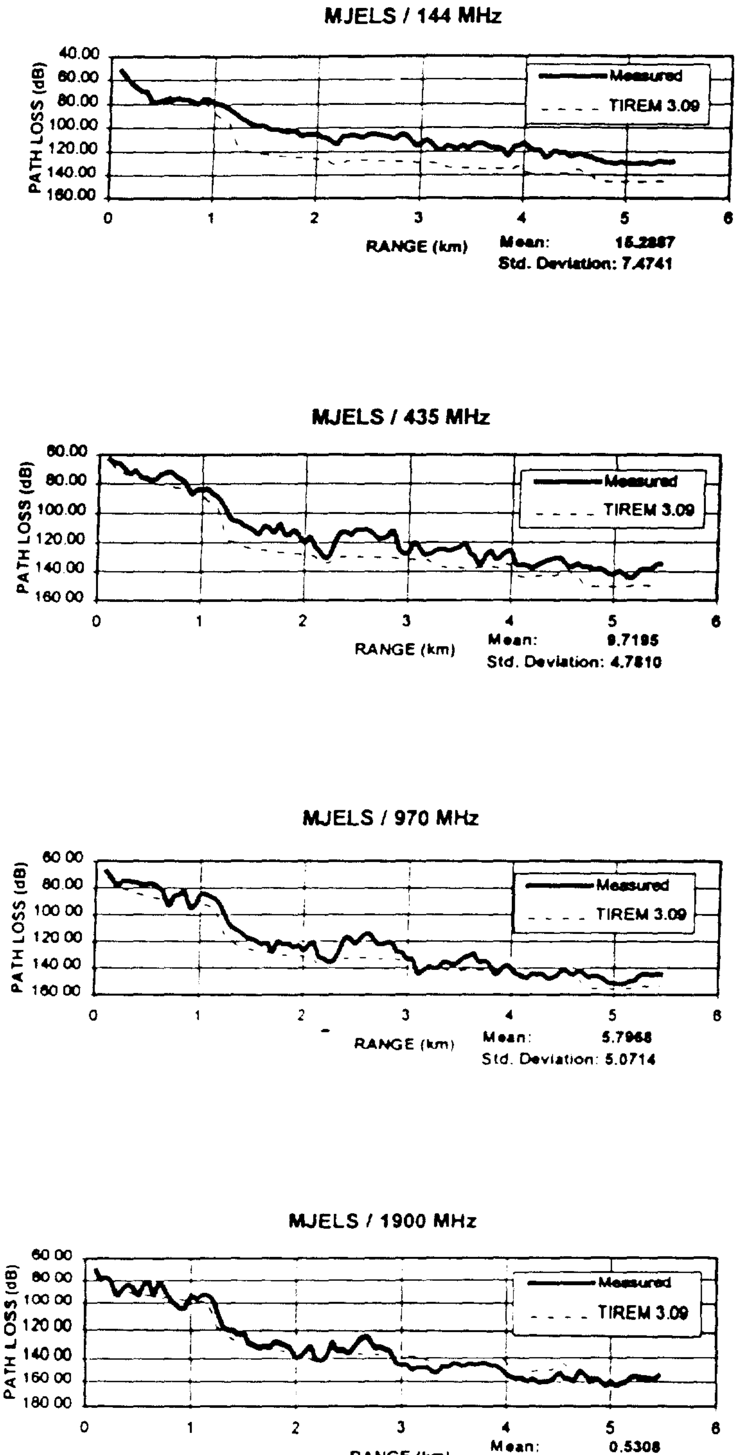


Figure 4-4. Comparison of TIREM 3.09 with measured data from Mjels

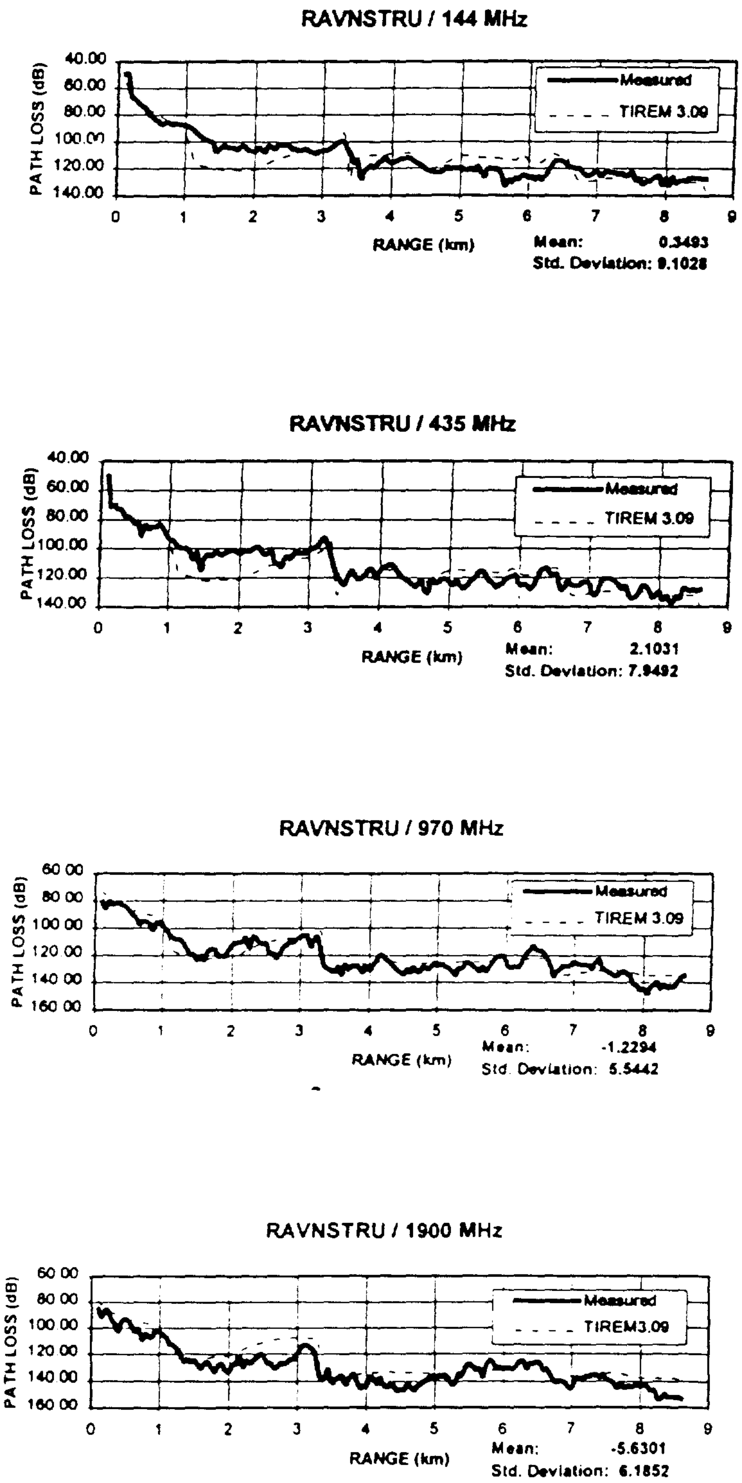


Figure 4-5. Comparison of TIREM 3.09 with measured data from Ravnstru

SECTION 3
CONCLUSIONS

Data contained in the NTIA Propagation Measurement Database was used to characterize the statistical accuracy of TIREM for a large number of test scenarios. The results of the verification of TIREM with this data show an overall mean of -0.6, and a standard deviation of 10.5 dB.

The comparison of TIREM with data collected by Anderson are provided as graphs of path loss versus range for various frequencies and geographical locations. For each graph a mean and standard deviation is also provided.

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